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Do Use and Disuse Modify Heredity?

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In considering this basic problem of evolution, it is evidently necessary to study the dynamics of heredity. The fact that all forms of life inherit the tendencies and powers of their ancestors is unquestioned. Fish beget fish, birds beget birds, and mammals beget mammals, each after its own kind. But how these tendencies and powers are transmitted through the egg, a one-celled body, is not so easy to comprehend.

The microscope shows that the egg consists of a cell wall, cytoplasm, concerned principally with nutrition, and nucleus, the part controlling cell division and bearing the hereditary qualities of the organism. All the parts named, the wall, the cytoplasm and the nucleus, are composed of protoplasm, the physical basis of life according to Huxley. Associated with the protoplasm of the egg are various hydrocarbons and carbohydrates, which yield energy for the cell activities when oxidized, and certain other food materials not yet assimilated.

Naturally the evolutionist is interested chiefly in protoplasm. The chemist tells him that it consists of an unknown number of kinds of protein, many of which are of unknown chemical composition. The biologist with the microscope can distinguish several varieties of protoplasm, chiefly from the fact that they absorb various aniline dyes in different degrees. One of these, which he has named chromatin, absorbs more of the dye stuff than any other, and is the most active kind of protoplasm in the cell in cell division, and hence is most interesting. The other kinds have special work to do in nutrition and in assisting the chromatin, but are not thought to have much to do in heredity. The centrosomes and linin threads, however, merit watching. The centrosomes initiate cell division in most animal cells and in the cells of the lower plants. The linin threads manage the details of cell division.

All the cells of all the tissues are derived from the fertilized egg cell through the process of cell division and growth of each cell from absorbed nourishment. All the daughter cells become specialized in a remarkable way as soma cells. Every cell of the body can do seven things, but the soma cells become specialized so they can do one of the seven things better than they can do the other six. The cells lining the alimentary canal are adept in the absorption of nourishment. The gland cells are wonderful chemists. Other cells are chiefly interested in the excretion of waste. The egg and sperm cells continue the species. The cells of the special senses receive sensations. The muscle cells can contract so as to bring about movements of the parts of the body. The ganglion cells of the nervous system can do or not do many things for the good of the animal.

When the fertilized egg cell divides, each resulting cell has the contract for forming half of the body of all symmetrical animals, or, should the cells separate, the daughter cells may produce identical twins as in man. As the daughter cells increase in number by cell division, and in size through the absorption of nourishment, they assemble in tissues and organs, change their shape and structure, all as

though they were obeying the word of command of some supervising architect. The inherited blue prints in these cases are followed with few mistakes and no cheating. The egg and sperm cells of adult animals have a specialization no more wonderful than that of the other soma cells. They have their special work to do and accomplish it in accordance with the inherited tendencies of their species.

The one question of absorbing interest to all students of life, whether plant or animal, is, Who is the supervising architect, and how are his plans executed? Materialistic biologists have attempted to answer this question, but their biogens, biofors, determinants and energy reactions lie peacefully sleeping in the scrap heap of mere hypotheses.

It is the purpose of this paper to prove by direct evidence, that changes in the habits of animals (and plants as well) are registered slowly but surely in the body-building and body-using instincts of the succeeding generations.

In the Eocene period of the Tertiary era, as shown by their fossil skeletons, little horses grazed on the tender herbage of the swamps of western Kansas and Nebraska. These horses had four well-developed toes on their fore feet and three toes on their hind feet, all being useful in supporting the animals in the bog-lands. The five-toed ancestors of these Eocene horses have not yet been discovered, but skeletons with the missing first digit will undoubtedly be unearthed in the near future.

As western Kansas and Nebraska became higher and drier with the upheaval of the Rocky Mountains, Eohippus depended more and more on speed to escape the wolves and fierce cats. In running the little horses used the third digit chiefly, the second and fourth digits somewhat, and the fifth digit not at all. Slowly the third digits increased in size, and the fifth digits diminished till they became rudimentary and disappeared. It took one million years, according to Osborn, to lose the fifth digit through disuse. In the Miocene Tertiary all the horse skeletons show but three toes. As the horses became larger and the plains higher and drier, the horses used the third digit more exclusively. The third digits with their nails or hoofs grew in size with use and became the main and finally the only supports of the body. The second and fourth digits diminished in size with disuse and are now rudimentary. These digits are represented in the modern horse by the so-called splint bones, rudiments beneath the skin, of the metacarpal and metatarsal bones of these digits. Two additional million years were required to dispose of these side digits and make the American Quaternary horse an apparently one-toed animal.

The instinct in the horse for developing five digits on each leg is not entirely lost. According to Professor Wentworth of our Agricultural College, himself an authority on animal breeding, Dr. J. Cossar Ewart of Copenhagen says that three toes are found in the embryos of all horses at about the fifth or sixth week. In draft horse embryos vestiges of all five toes, according to Doctor Ewart, persist till the same period. Chestnuts and ergots on the legs of horses are usually regarded as representing the hoofs of the missing digits. The paleontologist can furnish dozens of examples showing the influence of environment in causing

modification of parts through use or disuse. Osborn describes the Zeuglodon, which became dog-like after having been a tree-inhabiting animal; later it took to the water and became a fish-like, and later an eel-like mammal.

Whenever a need continues for many years animals not overspecialized against it will modify their anatomy to meet the need, even if it takes a million years or more to do so. Osborn says that all the radiating descendants of a group of hornless mammals may at different periods of geologic time give rise to similar horny outgrowths upon the forehead. The horny outgrowths were long needed for self-defense, and in time they came. Natural selection helped after the horns appeared, but did not start them or make them grow.

The examples are almost numberless wherein the needs of the working cells of the body are impressed on the chromatin of the egg and sperm cells, and the fertilized egg cell has reacted and made provision to meet the need in the course of milleniums of time, but how was the knowledge of the need transferred to the chromatin of the egg and sperm cells? The fact of the transferal is demonstrated; the method of transfer is not understood with certainty.

Several ductless glands, such as the pituitary body at the base of the brain, the thyroids, parathyroids and thymus glands of the neck, and the suprarenals on the kidneys, all have a marked influence in stimulating or retarding the growth of various parts of the body through matter added to or subtracted from the blood. Various glands with ducts, such as the pancreas, liver and reproductive glands, share with the ductless glands the power to send accelerators or restrainers through the blood to various parts of the body. When the pituitary body is injured in a young mammal, such as a dog or sheep, the animal is dwarfed in size, has an excessive development of adipose tissue, and has a delayed or imperfect sexual development. When the same gland is stimulated by disease, unusual growth of various parts of the body takes place. All have observed the remarkable results which have followed the castration of young males, and similar modifications of the development of various parts of the body follow the extirpation of the other glands mentioned.

It is certain that the blood receives from the cells of these glands certain tiny bodies which produce the effects named. Some of these particles, named antibodies, confer immunity to germ diseases; others, named hormones, stimulate the growth of distant organs; and still others, named chalcones, depress, retard or inhibit the activity of distant parts.

Jordan says that the germ causing influenza is $\frac{1}{2500}$ mm. by $\frac{1}{5000}$ mm. in size, and the germ of infantile paralysis, measuring $\frac{1}{5000}$ mm., is on the limit of microscopic vision. Beyond these, according to Jordan, are the ultramicroscopic bacteria, beyond the range of vision, some of which can pass through a porcelain filter.

If one-celled plants can be beyond the range of microscopic vision, is it any wonder that tiny messengers sent out by the chromatin of gland cells, or any other cells of the body, should escape observation? These messengers may be poured into the blood by any overworked cell and

hastened in its swift current to auxiliary parts of the body for help in the shape of nourishment and oxygen. Some of these outshoots of chromatin may find developing germ cells and modify to a slight degree the inheritance of the next and succeeding generations. This would be no more wonderful than the changes produced in distant parts of an organism by antibodies, hormones and chalone.

It is fortunate for each species of plant and animal that the changes in inheritance come slowly, keeping pace with the changes in the average environment, otherwise the plant or animal might not survive in its struggle for existence. In the geologic history of the earth many forms have failed to keep pace with their environment, or have advanced too rapidly, and in consequence have perished. Thousands of plants and animals that varied in the wrong direction, or too rapidly, or too slowly, were destroyed in the different periods of the earth's history, but other thousands of their relatives varied with their environments and therefore survived to continue earth's faunas and floras.

While the hormones (stimulators), chalone (retarders) and antibodies (immunizers) may not be alive, they originate in living cells and act on living cells, and hence owe their efficiency in guiding the development of plants and animals to protoplasm energized through life. It is life that is the variable and produces variations in organisms.

Darwin himself fully understood the limitations of his theory of natural and artificial selection. He knew that selection alone could not originate a part of a plant or animal or even modify it. Selection can merely sit in judgment on the work of conscious use or disuse, and reject the individual when it is harmful to the species, or accept the individual when it is helpful. The effects alone of conscious use and disuse of cells, tissues and organs can be inherited. Each tissue and organ had its beginning so long ago in time, and so far down in the plant or animal kingdom, that the cells were at first but slightly modified by life, and millions of years were required to bring the tissue or organ to perfection. Once completed, other millions of years are needed to lose the part, so slowly are species-instincts changed by life through disuse.

A Probable Case of Superfetation in the Cow.

MARY T. HARMAN.

Contribution from the Zoölogical Laboratory of the Kansas State Agricultural College, No. 21 (abstract).

A cow which was mated on December 22, 1916, gave birth to a calf on September 27, 1917. The calf was a normally developed female slightly above the average in size. On October 1 this cow gave birth to another calf, which, according to the decision of the veterinarian, was a little more than a four months' fetus. This second calf was inclosed in the animon, and the placenta was in good condition. Although the calf was dead when born, the death had evidently occurred only a short time previously, as there was no indication of decay.